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Influence of Infill Wall in the Performance of RC Structure Subjected to Seismic Load

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***Abstract*—Masonry Infill Walls plays considerable role in performance of structure subjected to Seismic Load. As masonry infill walls were treated as non-structural member in R.C structures and its contribution were not considered in analysis and design of structure. Various types of infill walls gives various types of structural behaviour. Masonry Infill provide remarkable lateral stiffness & strength. But also it has some undesirable effects like soft storey and short column effect. Researchers established some simulation techniques to analyse structures with infill wall. In present paper, experimental study on 30 & 40 floor reinforced concrete frame buildings subjected to lateral load modelled and analysed using ETABS by Response Spectrum Method and justified the revision of IS1893:2002 in the for the contribution of infill wall in latest version.**

***Index Terms*—Masonry Infill (MI) Wall, Reinforced Concrete (RC) frame, Performance**

I. Introduction

Most of the reinforced concrete frame structures are infilled with masonry walls for the purpose of separation or/and privacy. In conventional practice it is considered that infill wall doesn’ t take any load so for analysis and design of structure the role of infill wall is neglected and self-weight of infill is considered for design of other structural members. But it has been observed that frames with MI walls have a very high initial lateral stiffness and low de-formability. Because of infilling frames with masonry walls the lateral-load transfer mechanism of the structure changes from predominant frame action to predominant truss action, which leads to increase in axial forces and reduction in bending moments in the frame members.

Due to uncertain position of masonry infill walls and openings in buildings there are irregularities in plan and elevation. Often MI walls are rearranged as per functional needs of the occupants, because of these changes there are adverse effects on the overall structural behaviour as it leads development of unsymmetrical stiffness in structure leading to global torsion. Thus it is difficult to construct a regular masonry infill wall RC frame structure and also it cannot be taken for granted that it will remain regular after it is constructed.

Various modelling methods are available to stimulate the infill wall in RC frame and by using these modelling methods the analysis can be done. Various researchers studied and analyzed infill wall RC frames and the need of inclusion of these non-structural elements on the structural seismic assessment and design process is recognized.

Infill wall - It is a panel constructed from masonry usually built in between columns and beams of structural frame of building. Masonry walls are made up of clay units, aggregate concrete units and autoclaved aerated concrete units. In most design practices infill walls are constructed as non-structural element. But in some high and moderate seismic zones it is taken into consideration (Eurocode 8, 1994; NBC 201, 1994) and now in IS1893:2016.

Masonry infill wall panels increase strength, stiffness energy dissipation and decreases ductility of the building. More importantly, they help in drastically reducing the deformation and ductility demand on RC frame members. Some ill effects are also seen such as short column effect, torsion effect and soft storey effect.

Types of Infill Wall:

A. Based on Material

1. Masonry Infill Walls
2. Light Steel Frames Infill Walls
3. Concrete Infill Walls
4. Timber Framed Infill Walls

B. Based on Provisions

1. Bare Frame
2. Full Infill
3. Infill with Opening
4. Partial infill frame

When lateral load comes on bare frame as shown in fig. a load is transferred by predominant frame action i.e. moments developed at column and beam junction. Whereas after introduction of infill wall the predominant frame action changes to predominant truss action. Because, compression strut is formed along one diagonal and tension comes along other diagonal. The bending moment is reduced and axial forces are increased in the members.

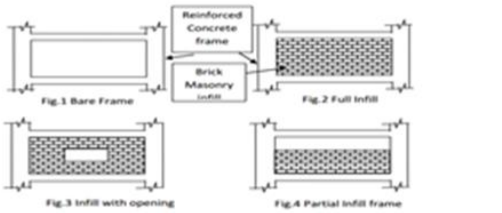

Fig. 1. Effect of lateral load on MC-RC frame

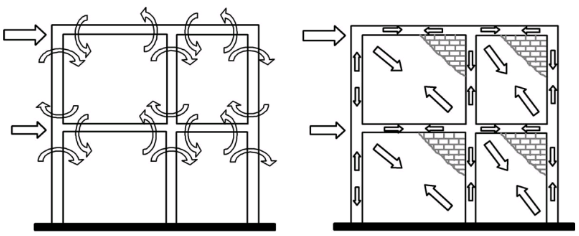
(a) (b)

Fig. 2 (a) Predominant frame action (b) Predominant truss action

As masonry infill walls are laterally stiffer than RC frames and therefore Failure in Infilled Frames.

A. Shear friction failure
B. Diagonal tension failure
C. Compressive failure

A. Shear Friction Failure

The shear forces in the columns may exceed the maximum along the contact length, near the loaded corner. Sliding along mortar joints expedite the shear failure of the column due to develop a short column effect.

B. Diagonal Tension Failure

Large shear forces and bending moment in the loaded corner and along the contact length in the zones near loaded corner can develop wide diagonal cracks running across the from the interior to exterior corner.

C. Compressive Failure

Failure due to axial load: Gravity loads and the truss mechanism produce axial compressive forces in the columns. Buckling of the longitudinal reinforcement may occur due to severe cyclic loading and resulting in a compressive failure. However, this failure mode is not very common because of high compressive strength of the columns.

II. Modelling of Infill Frames

Several analytical models have been proposed by researchers to understand the behavior of infill panels. These models are mainly classified into two groups i.e. micro and macro.

A. Micro Modelling

In micro modelling infill walls are represented by using finite element method. The finite element method is the most popular analysis method for complex structural engineering problem. Several difficulties shown from the simulation, including modeling the connection of frame and infill, The connection strength and friction of frame and infill. Gives detailed results but its use is limited as it takes greater effort in computation for analysis and modeling as the elements constructed for building are not isotropic.

B. Macro Modelling

In macro modelling infill walls are represented by equivalent struts. Analysis and modeling of infill wall gets easy in frame structure with equivalent strut method with considerably lesser efforts in computation.

a) Single Equivalent Strut Model
b) Double Equivalent Strut Model
c) Triple Equivalent Strut Model

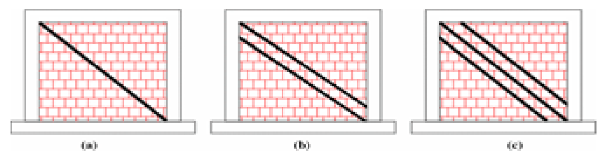
Fig. 3. Macro modelling

III. Experimental Study

Given data and version parameters those are considered in the performance analysis present is listed below:
R.C.C building (G+30) storey model having relative storey height 3.5 m. Two categories of models are considered according to the profile in plan.
1. Square Building Plan - 30m×30m.
2. Rectangular Building Plan - 20m×45m.
The area is considered under seismic zone III (Mumbai) and Medium type of soil is considered for analysis.

A. Material

1) Concrete

Characteristic Compressive Strength (f_{ck}) = 25Mpa
Poisson's Ratio = 0.3
Density = 25 KN/m^3
Modulus of Elasticity (E) = 5000* = 25000Mpa

2) Steel

Fe 500 grade steel =500 Mpa
Modulus of Elasticity (E) =2 x 10^5 Mpa

3) Masonry Infill

Clay Burnt Brick, Class A, Confined Unreinforced Masonry
Size of Brick = 19*9*9 cm
Compressive Strength of Masonry (Fm) = 10Mpa
Modulus of Elasticity of Masonry (Em) = 550*Fm = 5550Mpa
Poisson's Ratio for Masonry = 0.15
Proportion of Cement and Sand in Mortar for Masonry =1:4
Unit Weight of Masonry = 19 KN/m^2

4) Frame Elements

Thickness of R.C.C. Slab = 0.15m
Size of R.C.C. Beam = 0.30m*0.50m
Size of R.C.C. Column = 0.50m*0.50m
Width of Compressive Strut (w) = 0.670m

B. Loads

Following load combination are considered as per I.S.1893 (Part 1): 2002

1.5(DL + LL)
1.2(DL + LL ± ELx)
1.2(DL + LL ± Ely)
1.5(DL ± ELx)
1.5(DL ± Ely)
0.9(DL ± 1.5 ELx)
0.9(DL ± 1.5 Ely)

C. Width of Equivalent Strut

Calculated using the equation suggested by FEMA.

$$W_{eff} = 0.175 \times (\lambda_h \times H)^{-0.4} \sqrt{H^2 + L^2}$$

$$\lambda_h = \sqrt[4]{\frac{E_{inf}\ t\ Sin\ 2\theta}{4\ E_c\ I_c H_{inf}}}$$

Length of strut Ls = $\sqrt{3.5^2 + 5^2} = 6.1032$

$\theta = \sin^{-1}(3.5/6.10) = 35^\circ$

$I_c = (b \times d^2)/12$

$E_c = 5000 \times \sqrt{f_{ck}}$

$E_c = 5000 \times \sqrt{25} = 25000$ MPa

$E_m = 550 \times f_m$

$E_m = 550 \times 10 = 5550$ MPa

t (thickness on infill panel) = 230 mm

h_m = (height of infill panel) = 3500 mm

$$\lambda_h = \sqrt[4]{\frac{5000 \times 230 \times Sin(2 \times 35)}{4 \times 25000 \times 5.2083 \times 10^9 \times 3500}}$$

$\lambda_h = 9.0065 \times 10^{-4}$

$W_{eff} = 674$ mm (Approximately=670 mm)

IV. Results Obtained from Analysis

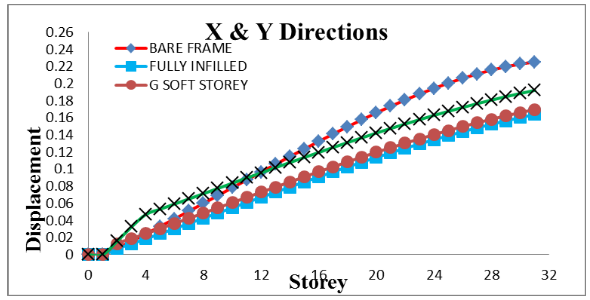

Fig. 4. Max. Displacement in X & Y dirt. (Square)

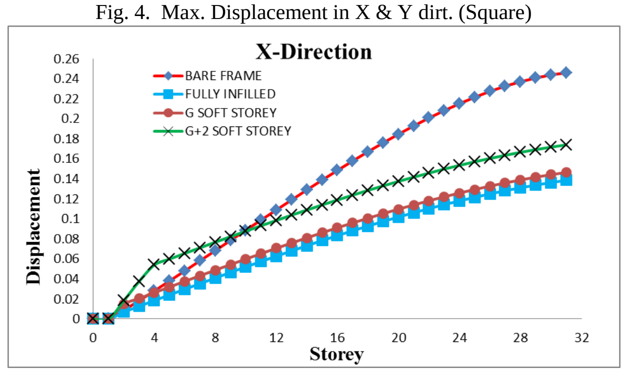

Fig. 5. Max. Displacement in X Dirt. (Rectangular)

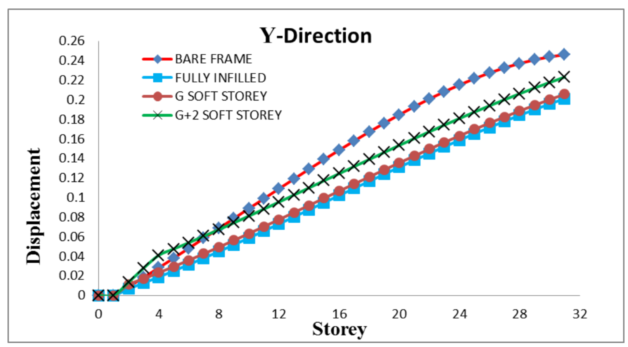

Fig. 6. Max. Displacement in Y Dirt. (Rectangular)

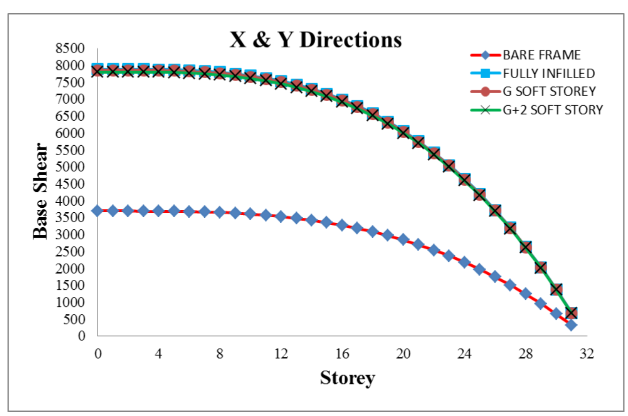

Fig. 7. Max. Storey Shear in X & Y Dirt. (Square)

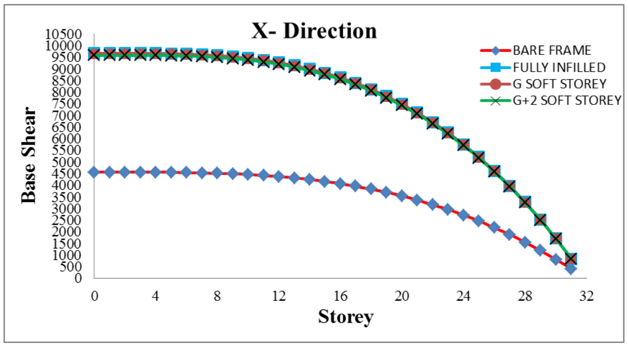

Fig. 8. Max. Storey Shear in X Dirt. (Rectangular)

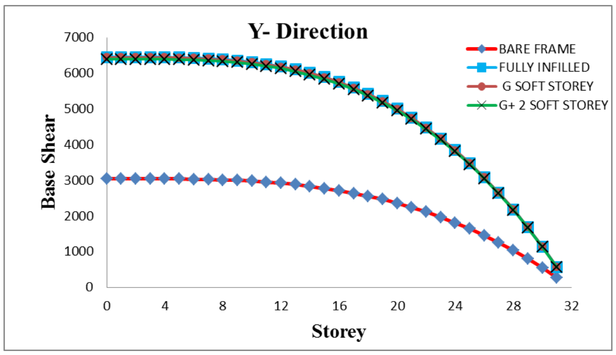

Fig. 9. Max. Storey Shear in Y Dirt. (Rectangular)

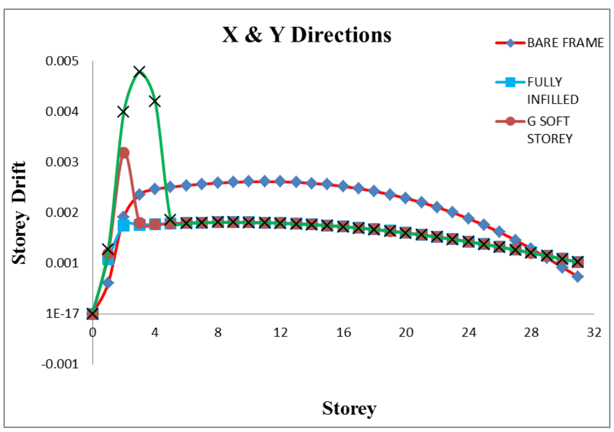

Fig. 10. Max. Storey Drift in X & Y Directions (Sq.)

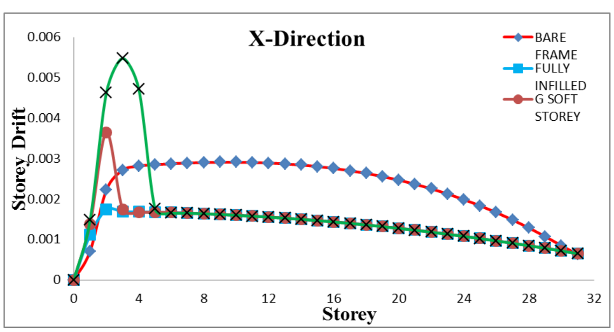

Fig. 11. Max. Storey Drift in X Dirt. (Rectangular)

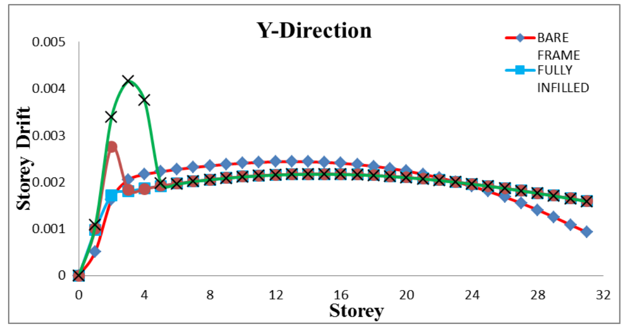

Fig. 12. Max. Storey Drift in Y Dirt. (Rectangular)

V. CONCLUSION

1. Time period:

Geometry of structure influences time period of structure. Time period is greater in rectangular building as compare to square building having same plan area due to the lesser stiffness offered by short direction. The time period decreased by 42% by addition of infill walls and it increases as number of soft stories increases.

2. Max. storey displacement:

The maximum storey displacement decreases by approximately 30% in fully infilled frame as compare to bare frame. The maximum storey displacement increases as number of soft storey increases as compare to fully infilled frame. As the length of building dimension increases maximum storey displacement decreases.

3. Base shear:

Base shear increases by approximately 110% in fully infilled frame as compared to bare frame. Because the extra masonry load acts on fully infilled frame than bare frame.

4. Storey drift:

Drift distribution is sudden rise near ground and afterwards gradually decreasing towards the top of model which is been considerably reduced along the whole structure in the model with strut.

In g.f. soft storey, the storey drift increases by approximately 1.7 times than bare frame and 1.8 times than fully infilled frame. In g+2 soft storey, the storey drift increases by approximately 2 times than bare frame and 2.7 times than fully infilled frame.

REFERENCES

[1] Kocak, a. Kalyoncuoglu & b. Zengin, 2013, "Effect Of Infill Wall And Wall Openings On The Fundamental Period Of Rc Buildings", in transactions on the built environment, vol. 132, issn 1743-3509.
[2] Akshay grover & dr. S. K. Verma, july 2016, "Effect Of Infill Walls On Rc Framed Structure", international journal of innovative research in science, engineering & technology, vol. 5, issn 2319-8753
[3] C. V. R. Murty & s. K. Jain, 2000, "Beneficial Influence Of Masonry Infill Walls On Seismic Performance Of Rc Frame Buildings", 12th world conference on earthquake engineering, New Zealand, paper no. 1790.
[4] Diptesh das & c.v.r. murty, july 2004, "Brick Masonry Infill In Seismic Design Of Rc Framed Building, Part1-Cost Implications", the indian concrete journal.

[5] H. B. Kaushik, d. C. Rai, m.eeri and s. K. Jain, "Code Approaches To Seismic Design Of Masonry-Infilled Reinforced Concrete Frames: A State-Of-The-Art Review", earthquake spectra, volume 22, no. 4, pages 961-983, november 2006; 2006, earthquake engineering research institute.

[6] V. N. Rathod, B. S. Munjal and s. M. Kulkarni, "Seismic Performance Assessment Reinforced Concrete Structure With Masonry Infill Wall", volume 3, issue 2, 2015, international journal of engineering development and research.

[7] R. A. Deshmukh and P. S. Pajgade, "A Study of Infill Material on Seismic Performance of RC Buildings", international journal of engineering sciences & research technology.

[8] M. S. Razzaghi and m. Javidnia, 2015, "Evaluation of Effect of Infill Walls on Seismic Performance of RC Dual Frames", int j adv struct engg (2015)49-54.

[9] K. A. Korkmaz, f. Demir, h. Tekeli, a. E. Karohan, 2008, "Effects Of Infilled Masonry Walls On Nonlinear Structural Behaviour Of Precast Concrete Structure In Turkey", the 14th world conference on earthquake engineering, beijing, china.

[10] Malcolm holmes, "Steel Frames With Brick Work And Concrete Infilling", paper no. 6501.

[11] Nikhil agrawal, P. B. Kulkarni, pooja raut, (2013), "Analysis of Masonry Infill RC Frames with and without Opening Including Soft Storey Using Equivalent Diagonal Strut Method", international journal of scientific and research publication, volume 3, issue 9, sept 2013.

[12] Bryan stafford smith, "Methods For Predicting The Lateral Stiffness And Strength Of Multi-Storey Infilled Frames", building science, pergamon press, 1967, vol.2, pp. 247-257.

[13] Mohammed nauman, nazrul islam, january 2014. "Behaviour Of Rcc Multi Storey Structure With And Without Infill Walls", international journal of innovative research in science, engineering & technology, vol. 3, issn 2319-8753

[14] Is 1893:2002, Indian Standard Criteria For Earthquake Resistant Design Of Structures, part 1, bureau of indian standards, new delhi, 2002.

[15] Is 456:1978, Indian Standard Code of Practice for Plan and Reinforced Concrete, Bureau of Indian Standards, New Delhi, 1978.

[16] S.s. kumbhar & r.s. rajguru, june 2015, "Seismic Analysis Of Masonry Infill In Multi Storey Rc Buildings", international journal of science, engineering & technology research (ijsetr),vol. 3, issue 6.

[17] Andre furtado, antonio arede, hugo rodrigues, august 2014, "Evaluation Of The Effect Of Masonry Infill Walls Presence In Existing Rc Structures", forecast engineering: global climate change and the challenge for built environment, weimar, germany.

[18] Ahmed sayed, ahmed tewfik essa & mohamed ragai kotp badr, december 2013, "Effect Of Infill Walls On The Ductility And Behaviour Of High Strength Reinforced Concrete Frames", housing and building national research centre (hbrc).

[19] Andre furtado, antonio arede, hugo rodrigues, "Modelling Of Masonry Infill Walls Participation In The Seismic Behaviour Of Rc Buildings Using Open Sees: Numerical And Experimental Study".

[20] Ms. Rajashri a. Deshmukh , P. S. Pajgade ,january 2015, "A Study Of Effect Material On Seismic Performance Of RC Buildings", international journal of science, engineering & technology research (ijsetr),

[21] Santiago pujol, amadeo benavent-climent,mario e rodriguez and j. Paul smith-pardo, october 2008, "Masonry Infill Wall: An Effective Alternative For Seismic Strengthening Of Low-Rise Reinforced Concrete Building Structure", the 14th world conference on earthquake engineering.